

EWF Special Course

Personnel with the responsibility for Macroscopic and Microscopic Metallographic Examination of Structural Materials and their Joints
Prepared/Produced by Welding and Allied Techniques



Minimum Requirements for the Education, Examination and Qualification



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Section I: Minimum Requirements for the Education

The use of this guideline is restricted to organizations approved by the Authorized National Body (ANB)

1. Introduction

Mechanical, physical and chemical properties of metals and alloys are determined essentially by their structure. Therefore the metallographic examination is widely used for determination of both macro- and microstructure of metals and their alloys. Metallographic examination enables to assess the influence of various kinds of processes and technological treatment, for instance metallurgical processes, plastic working, welding and allied processes, heat treatment etc. on changes occurring in the structure of metals and their alloys.

Metallographic examination belongs to the group of destructive tests because the preparation of suitable specimen is connected inherently with the injury to the whole of the test element.

In the present-day welding technology, in relation to welded joints and those made by allied techniques, metallographic examination is employed on a very large scale, namely:

- a) in testing of weldability of materials appropriated for welding,
- b) in verification of welding personnel qualifications (welders, welding operators),
- c) in development of welding consumables (filler metals, fluxes etc.),
- d) in development of new methods of welding, surfacing, brazing, soldering and thermal cutting,
- e) in determination of optimum conditions of welding, weld surfacing, brazing, soldering and thermal cutting,
- f) in current control of welding processes (in testing of joints or test elements),
- g) in final control of welded, brazed or the like products,
- h) in testing of conditions of arising of welding defects and imperfections,
- i) in determination of reasons of failures of structures and products made by welding and allied methods.

The course „MACROSCOPIC AND MICROSCOPIC METALLOGRAPHIC EXAMINATION OF STRUCTURAL MATERIALS AND THEIR JOINTS PREPARED/PRODUCED BY WELDING AND ALLIED TECHNIQUES” is a three-level course:

COMPREHENSIVE LEVEL: “Advanced techniques in metallographic examination of structural materials and their joints prepared/produced by welding and allied techniques”.

STANDARD LEVEL: “Macro- and microscopic examination of structural materials and their joints prepared/produced by welding and allied techniques”

BASIC LEVEL: „Specimens preparation for macro- and microscopic examination of structural materials and their joints prepared/produced by welding and allied techniques”.

The course is oriented to the application of metallographic examination of joints of the following structural materials :

- carbon and alloy structural steels,
- plain and alloy cast irons,
- aluminum and copper alloys,
- titanium alloys,
- nickel alloys,
- thermoplastics.

Type or types of structural materials will be chosen upon the request of students for the course.

The guideline covers the minimum requirements for education and training, agreed upon by all national welding societies within the EWF in terms of objectives, keywords and recommended times devoted to them. It will be revised periodically by the Committee to take into account any changes which may affect the “state of the art”. Students having successfully completed this course of education will be expected to be capable of applying preparation and assessment of specimens for metallographic investigations as covered by this guideline. A subsequent document covers the examination and qualification.

2. Education program

A teaching hour will contain at least 50 minutes of direct teaching time. It is not obligatory to follow the order of the topics given in this guideline and choice in the arrangements of the syllabus is permitted. The depth to which each topic is dealt with is indicated by the recommended number of hours allocated to it in the Guideline. This will be reflected in the scope and depth of the examination.

COMPREHENSIVE LEVEL: “Advanced techniques in metallographic examination of structural materials and their joints prepared/produced by welding and allied techniques”.

Course profile:

The main purpose of this course of the COMPREHENSIVE LEVEL is to present to the students advanced testing techniques and interpretation of the macroscopic and microscopic examination results of structural materials and their joints.

The programme of the COMPREHENSIVE LEVEL course is a survey of necessary theoretical and practical issues, which the students should learn in order to get the knowledge regarding advanced techniques used in metallographic examination.

The contents are given in the following structure:

Ser. no.	Subject	Number of theoretical teaching hours	Number of practical teaching hours
1	The types of metallographic examination; work safety conditions during preparation of specimens for metallographic examinations	1,0	-
2	Methods of specimen preparation for macro- and microscopic examination	3,0	-
3	Macroscopic examination and its application in welding technology	0,5	-
4	Microscopic examination and its application in welding technology	0,5	-
5	Demonstration of specimen preparation manners for metallographic examination	-	6,0
6	Electrolytic polishing, chemical polishing, coloured etching – purpose and application	5,0	-
7	Demonstration of electrolytic polishing and coloured etching	-	3,0
8	Demonstration of different kinds of microscopic structures	-	2,0
9	Image analysis as a tool in metallographic examination	6,0	-
10	Demonstration of capabilities of the program for image analysis	-	4,0
11	Introduction to scanning microscopy	5,0	-
12	Demonstration of scanning microscope capabilities	-	4,0
13	Practical examination	-	3,0
14	Written (test) examination	2,0	-
		23,0	22,0

STANDARD LEVEL: “Macro- and microscopic examination of structural materials and their joints prepared/produced by welding and allied techniques”

Course profile:

The main purpose of the STANDARD LEVEL course is to present characteristics of defects in joints prepared by welding or allied processes according to the standards and to present the interpretation of the results of macro and microscopic examination .

The programme of the STANDARD LEVEL course is a survey of necessary theoretical and practical issues which students should learn in order to have the knowledge and skill for the assessment of joints quality using macro- and microscopical examination. To this end, pieces of both homogeneous material and their joints of chosen structural materials will be performed.

The contents are given in the following structure:

Ser. no.	Subject	Number of theoretical teaching hours	Number of practical teaching hours
1	The types of metallographic examination; work safety conditions during preparation of specimens for metallographic examinations	1,0	-
2	Methods of preparation of specimens for macro- and microscopic examination	3,0	-
3	Macroscopic examination and its application in welding technology	0,5	-
4	Microscopic examination and its application in welding technology	0,5	-
5	Presentation of the EN 1321 standard	1,0	-
6	Demonstration of specimen preparation manners for metallographic examination	-	2,0
7	Practical training in specimen preparation	-	4,0
8	Presentation of standards relating to the quality assessment of joints made by welding and allied techniques	16,0	-
9	Demonstration of assessment of macroscopic specimens of joints	-	3,0
10	Demonstration of different kinds of microscopic structures	-	1,0
11	Practical training in unaided identification of welding imperfections on macroscopic specimens	-	6,0
12	Practical training in unaided identification of structures in microscopic specimens	-	2,0
13	Practical examination	-	3,0
14	Written (test) examination	2,0	-
		24,0	21,0

BASIC LEVEL: „Specimens preparation for macro- and microscopic examination of structural materials and their joints prepared/produced by welding and allied techniques”

Course profile:

The essential question for carrying out metallographic examination properly is suitable and correct preparation of specimens for examination of this type.

Therefore the main purpose of this course is to instruct students how to prepare specimens for macro- and microscopic examination as well as to introduce the interpretation of the examination results.

The programme of the BASIC LEVEL course is a survey of necessary theoretical and practical issues which the students should learn in order to get the basic knowledge about preparation of specimens for macro- and microscopic examination. Because this course is of practical nature, its

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essential part is the instruction of the students in the manners of specimen preparation for metallographic examination.

To this end, specimens of both homogeneous materials and their joints prepared by welding or allied processes of structural materials will be prepared according to the individual demand of the course attendees.

The contents are given in the following structure:

Ser. no.	Subject	Number of theoretical teaching hours	Number of practical teaching hours
1	The types of metallographic examination; work safety conditions during preparation of specimens for metallographic examinations	1,0	-
2	Methods of specimens preparation for macro- and microscopic examination	3,0	-
3	Macroscopic examination and its application in welding technology	0,5	-
4	Microscopic examination and its application in welding technology	0,5	-
5	Presentation of the EN 1321 standard	1,0	-
6	Practical training in preparation of specimens for metallographic examination	-	24
7	Practical examination	-	3,0
8	Written (test) examination	2,0	-
		8,0	27,0

3. Access to the Education

Candidates for students of the STANDARD LEVEL and COMPREHENSIVE LEVEL course shall possess, at least, secondary technical education in mechanical branch. The candidates with another secondary education than mechanical one or with professional technical education in mechanical branch but with at least 3-year professional practice corresponding the course subject-matter are also admitted.

The candidates for the COMPREHENSIVE LEVEL course, who have completed the STANDARD LEVEL course, can be relieved from the duty to attend the part relating to the STANDARD LEVEL course and, in this case, they shall attend 32 lessons under the COMPREHENSIVE LEVEL.

The candidates for the COMPREHENSIVE LEVEL course, who have completed the BASIC LEVEL course, can be relieved from the duty to attend the instruction part relating to the BASIC LEVEL course and, in this case, they shall attend 31 lessons under the COMPREHENSIVE LEVEL.

The candidates for the STANDARD LEVEL course, who have completed the BASIC LEVEL course, can be relieved from the duty to attend the instruction part relating to the BASIC LEVEL course and, in this case, they shall attend 33 lessons under the STANDARD LEVEL.

Candidates for students of the BASIC LEVEL course shall possess, at least, professional technical education in mechanical branch. The people with another professional education than the mechanical one but with at least 2-year professional practice corresponding the course subject-matter are also admitted.

The BASIC LEVEL, STANDARD and COMPREHENSIVE LEVEL courses are independent of each other and can be conducted jointly or separately, according to the needs.

3.1 Requirements for candidates

All candidates shall provide evidence of a satisfactory visual test in accordance with the requirements of the standard EN 970.

4. Theoretical and Practical Education – Syllabus and Performance Objectives

Figures in the table are minimum teaching hours.

Theoretical education				
1. The types of metallographic examination; work safety conditions during specimen preparation				
Objective To get basic knowledge with regard to the purpose and classification of metallographic examinations. The importance of the industrial safety principles during preparation of metallographic specimens.				
Scope	Level of Qualification	Compre	Standar	Basic
	Teaching hours:	hensive	d	
- Definition of the term „physical metallurgy“; - Metallography as a part of physical metallurgy; - Classification of metallographic examination methods; - General characteristics of macroscopic examination; - General characteristics of microscopic examination; - Demonstration of the need of learning servicing instructions for grinding, polishing and etching devices situated in work stations; - Presentation of principles of safe handling chemical reagents applied for specimen surface etching		1	1	1
Expected Result: Knowledge in metallographic examination methods and their use. Characteristics of macro-and microscopic examination. Safety requirements for handling chemical reagents.				

2.Methods of specimen preparation for macro- and microscopic examination				
Objective: To present the stages of specimen preparation for macro- and microscopic examination. Devices for preparation. Instruction for safe storage of specimens for metallographic examination.				
Level of Qualification Teaching hours:		Compre hensive	Standar d	Basic
Scope				
- Presentation of sampling manners (mechanical or thermal cutting out, rough and precise cutting-off machines); - Presentation of specimen setting manners (mechanical grips, mounting of specimens); - Presentation of the stage of rough specimen grinding (disk-type grinding wheels); - Presentation of the stage of precise specimen grinding (grinding machines and abrasives); - Presentation of the stage of specimen polishing (polishing kinds, polishing machines and materials); - Presentation of specimen etching manners for macro- and microscopic examination (reagents for etching); - Presentation of specimen surface protection manners and storage before metallographic examination (varnishing, desiccators).		3	3	3
Expected Result: Knowledge about the sequence, tools, devices, reagents for metallography.				
3. Macroscopic examination and its application in welding technology				
Objective: To present the purpose and possibilities of practical application of macroscopic examination to homogeneous materials and their joints prepared by welding or allied processes.				
Level of Qualification Teaching hours:		Compre hensive	Standar d	Basic
Scope				
- Presentation of auxiliary equipment used in macroscopic examination (magnifying glasses, stereoscope microscopes of different types); - Specification of defects and imperfections which can be observed on specimens of homogeneous materials; - Specification of defects and imperfections which can be observed on specimens of joints; - Reference to the EN ISO 5817:2005 Welding. Fusion welded joints in steel, nickel, titanium and their alloys (beam welding excluded). Quality levels for imperfections; - Discussion of the scope of application of macroscopic examination in welding technology; - Presentation of exemplary results of macroscopic examination of welded joints.		0,5	0,5	0,5
Expected Result: Knowledge about equipments for macroscopic examination of joints prepared by welding and allied processes, defects and imperfection characteristics according to the EN ISO 5817.				

4. Microscopic examination and its application to welding technology				
Objective: To present the purpose and possibilities of practical application of microscopic examination to homogeneous materials and their joints prepared by welding or allied processes.				
Level of Qualification		Compre	Standar	Basic
Teaching hours:		hensive	d	
Scope				
- Presentation of the equipment used in microscopic examination; - Specification of defects and imperfections; - Discussion of the scope of application of microscopic examination in welding technology; - Specification of microstructures of joints prepared by welding and allied processes; - Presentation of results of microscopic examination of homogeneous materials and welded joints.		0,5	0,5	0,5
Expected Result: Knowledge about optical microscopes, the purpose of the microscopic examination. Microstructure characteristics of the joints prepared by welding and allied processes.				
5. Presentation of the EN 1321 standard				
Objective: To present the EN 1321:2000 Welding. Destructive tests on welds in metallic materials. Macroscopic and microscopic examination of welds.				
Level of Qualification		Compre	Standar	Basic
Teaching hours:		hensive	d	
Scope				
- Quotation of standards and documents referred by the EN 1321; - Discussion of the table containing guidelines for assessment of specific qualities in macro- and microscopic examination mentioned by the EN 1321; - Discussion of an exemplary report on macro- and microscopic metallographic examination of welded joints acc. to the EN 1321.		--	1	1
Expected Result: Knowledge in welds defects characteristics according to EN 1321.				

6. Presentation of standards relating to the quality assessment of joints made by welding methods and allied techniques

Objective: To present the content of standards relating to the quality assessment of joints made by welding and allied methods.

Level of Qualification Teaching hours:	Compre hensive	Standar d	Basic
Scope			
Discussion of the specifications in the following standards: a) EN ISO 6520-1:2002 Welding and allied processes. Classification of geometric imperfections in metallic materials. Part 1: Fusion welding; b) EN ISO 6520-2:2005 Welding and allied processes. Classification of geometric imperfections in metallic materials. Part 2: Welding with pressure; c) EN ISO 5817:2005 Welding. Fusion welded joints in steel, nickel, titanium and their alloys (beam welding excluded). Quality levels for imperfections; d) EN 30042:1998 Arc-welded joints in aluminium and its weldable alloys. Guidance on quality levels for imperfections; e) EN ISO 13919-1:2002 Welding. Electrons and laser beam welded joints. Guidance on quality levels for imperfections. Part 1: Steel; f) EN ISO 13919-2: 2002/A1:2005 Welding. Electron and laser beam welded joints. Guidance on quality levels for imperfections. Part 2: Aluminium and its weldable alloys (Amendment A1); g) EN ISO 18279:2005 Brazing. Imperfections in brazed joints; h) EN 13100-1:2002 Non destructive testing of welded joints of thermoplastics semi-finished products. Part 1: Visual examination; i) EN 12814-5:2002 Testing of welded joints of thermoplastics semi-finished products. Part 5: Macroscopic examination; j) EN 14728:2005 Imperfections in thermoplastic welds. Classification; k) ISO 17639: 2003 Destructive tests on welds in metallic materials. Macroscopic and microscopic examination of welds.	--	16	--

Expected Result:

Knowledge in imperfection characteristics of joints prepared by the welding or related processes.

7. Electrolytic polishing, chemical polishing, coloured etching - purpose and application

Objective: To present the principles, appropriation and application possibilities of electrolytic polishing, chemical polishing and coloured etching techniques in advanced metallographic examination.

Level of Qualification Teaching hours:	Compre hensive	Standar d	Basic
Scope			
- Electrolytic polishing technique – advantages and application scope; - Chemical polishing technique – advantages and application scope; - Coloured etching – purpose and application scope.	5	--	--

Expected Result:

Knowledge of the advanced techniques of specimen preparation for metallographic examination.

8. Image analysis as a tool in metallographic examination				
Objective: To present the techniques of image analysis used in metallographic examination.				
Level of Qualification Teaching hours		Comprehensive	Standard	Basic
Scope:				
- Idea and appropriation of the image analysis; - Equipment requirements for image analysis needs; - Manner and quality of surface preparation in metallographic specimens for image analysis needs; - Survey of programs for image analysis; - Presentation of the main functions of the program for image analysis (for instance: measurement of grain size, measurement of distance, detection of grain boundaries, identification of phases etc.); - Presentation of standards including criteria connected with image analysis, for example: EN ISO 643:2005 Steels. Micrographic determination of the apparent grain size.		6	--	--
Expected Result: Knowledge about principles and capabilities of the image analysis technique.				
9. Introduction to scanning microscopy				
Objective: To present the construction of the scanning microscope, the possibilities for the investigation of the welded joints quality.				
Level of Qualification Teaching hours:		Comprehensive	Standard	Basic
Scope				
- Scanning microscope – appropriation, kinds, application possibilities; - Preparation of specimens for scanning microscopy; - Examination techniques with the use of scanning microscope; - Fracture morphology evaluation, - Discussion of the specifications of the PN-EN ISO 9220:2001 Metallic coatings. Measurement of coating thickness. Scanning electron microscope method.		5	--	--
Expected Result: Knowledge of scanning microscope construction and examination techniques used for image analysis, fracture morphology characteristics for different loading (ductile, brittle, fatigue, corrosion etc.).				
10. Theoretical education – total number of hours		21	22	6

Practical training			
11. Practical training in preparation of specimens for metallographic examination			
Objective: Implantation of principles of correct proceeding during preparation of specimens for macro-and/or microscopic metallographic examination.			
Scope	Level of Qualification Teaching hours:	Compre hensive	Standar d
- Specimen setting by means of mechanical grips or mounting; - Precise specimen grinding with the use of a grinding machine and abrasive papers with different grain gradation; - Specimen polishing on polishing cloths with the use of a polishing machine and various abrasives (Al_2O_3 suspension or diamond based suspensions with different grain gradation); - Revealing of the macrostructure (chemical etching); - Revealing of the microstructure (chemical or electrolytic etching); - Observation of the specimen surface by the unaided eye or by means of instruments, for instance by means of a magnifying glass; - Protection of specimen surfaces against damage (for instance varnishing); - Observation of the specimen surface by means of an optical metallographic microscope within the magnification up to 1000$\times$.	--	4	24
Expected Result:			
Basic Level: Knowledge in the application of individual steps for specimen preparation.			
Standard Level: Knowledge in the application of individual steps for specimen preparation, defect types evaluation. Knowledge in stages of specimen preparation for metallographic examination. Implantation of basic principles of specimen preparation.			
12. Demonstration of specimen preparation manners for metallographic examination			
Objective: To present the principles and requirements a correct specimens preparation for macro-and/or microscopic metallographic examination.			
Scope	Level of Qualification Teaching hours:	Compre hensive	Standar d
- Specimens setting for metallographic examination by means of mechanical grips; - Cold or hot specimen mounting; - Precise specimen grinding with the use of a grinding machine and abrasive papers with different grain gradation; - Specimen polishing on polishing cloths with the use of a polishing machine and various abrasives (Al_2O_3 suspension or diamond based suspensions with different grain gradation); - Revealing of the macrostructure (chemical etching); - Revealing of the microstructure (chemical or electrolytic etching); - Observation of the specimen surface by the unaided eye or by means of instruments, for instance by means of a magnifying glass; - Protection of specimen surfaces against damage (for instance varnishing); - Observation of the specimen surface by means of an optical metallographic microscope within the magnification up to 1000$\times$.	6	2	--

Expected Result: Knowledge in different specimen mounting types, materials for grinding, polishing and etching and procedure for observation at high magnifications (up to 1000x).			
13. . Demonstration of macroscopic specimens assessment procedure of welded and allied joints			
Objective: to present the proper manner (order, hierarchy of welding defects and imperfections importance) of joint quality assessment on the basis of macroscopic specimens.			
Level of Qualification Teaching hours:	Compre hensive	Standar d	Basic
Scope			
Carrying out the quality assessment of different joints on the basis of the selected assessment criteria, e. g. according to the standard of EN ISO 5817.	--	3	--
Expected Result: Knowledge in defect classification according to EN ISO 5817.			
14. Demonstration of different kinds of microscopic structures			
Objective: to present the different kinds of metallographic microstructures of welded, brazed or soldered metallic joints.			
Level of Qualification Teaching hours:	Compre hensive	Standar d	Basic
Scope			
- Structures of parent material in initial state (after normalizing, plastic working etc.); - Structures in the heat affected zone (HAZ) – hardening structures, Widmanstätten structure etc.; - Structures in the weld metal area – primary and secondary structure.	2	1	--
Expected Result: Knowledge in the interpretation of micrographs taken from the steel base material (normalised, quenched and tempered, TMCP) and their welds.			
15. Practical training of identification of welding imperfections on macroscopic specimens			
Objective: to carry the quality assessment and to perform practical preparation of different welded, brazed or soldered joints for macroscopic examination.			
Level of Qualification Teaching hours:	Compre hensive	Standar d	Basic
Scope			
Identification and assessment of welding defects and imperfections in joints of different type.	--	6	--
Expected Result: To get practical experience in the defects assessment of welded joints prepared by different joining processes (steel, Al and Cu-alloys).			
16. Practical training of identification of microstructures in microscopic specimens			
Objective: Carrying out by the students of unaided identification of different metallographic microstructures in welded, brazed or soldered metallic joints.			
Level of Qualification Teaching hours:	Compre hensive	Standar d	Basic
Scope			
Unaided identification of metallographic microstructures of different kinds in metallic joints.	--	2	--

Expected Result: To get practical knowledge in the identification of the microstructure of welded joints prepared by different joining processes (steel, Al and Cu-alloys).			
17. Demonstration of electrolytic polishing and coloured etching			
Objective: To present the principles and the possibilities of electrolytic polishing, chemical polishing and coloured etching techniques application in advanced metallographic examination.			
Level of Qualification Teaching hours:	Compre hensive	Standar d	Basic
Scope			
- Electrolytic polishing technique – advantages and application scope; - Chemical polishing technique – advantages and application scope; - Coloured etching – purpose and application scope.	3	--	--
Expected Result: Knowledge in possibilities of the electropolishing and colour etching application.			
18. Demonstration of capabilities of the program for image analysis			
Objective: To present the principles of image analysis technique in metallographic examination.			
Level of Qualification Teaching hours:	Compre hensive	Standar d	Basic
Scope			
Demonstration of selected research-measurement capabilities of the program for image analysis: a) measurement of distances, b) measurement of grain size in steel microstructure, c) identification of phases in steel microstructure.	4	--	--
Expected Result: Knowledge in basic principles and capability of the image analysis.			
19. Demonstration of scanning microscope capabilities			
Objective: To demonstrate the scanning microscope and its application for metallographic examination			
Level of Qualification Teaching hours:	Compre hensive	Standar d	Basic
Scope			
Presentation of various examples of welded, brazed and the like joints using a scanning microscope.	4	--	--
Expected Result: Knowledge in application of scanning microscope for macro- and microstructure examination (defects, microstructure, fracture morphology)			
20. Practical training – total number of hours	19	18	24
21. Written examination	2	2	2
22. Practical examination	3	3	3
23. Total number of hours	45	45	35

Section II: Examination and Qualification

1. Introduction

The Guideline seeks to achieve harmonisation in the education, training, examination and qualification of macro- and microscopic examination of joints in Europe.

The national welding organisations, being members of EWF, mutually acknowledge the Qualification awarded by any Authorised National Body approved to implement this Guideline. This "Authorised National Body" (ANB) will normally be the National Welding and Joining Organisation, but may be another organisation with the agreement of the EWF Member.

Education must have followed this EWF guideline Section I, and the examination and approval tests must have been conducted by the National Body authorised by the EWF for this purpose.

2. Requirements for Training centres

Requirements for teachers and instructors, examiners, training establishments, courses are documented in the doc. EWF 416. Specific requirements for training centres are included in the Appendix A.

2.1 Approval of training course

Any training course leading to the EWF examination must be approved by the Authorised National Body in accordance with the doc. EWF 416. The number of teachers required to give the course shall be sufficient to ensure that the essential expert knowledge and industrial experience to cover the syllabus is adequately represented in the team of teachers and visiting lecturers.

3. Board of Examiners

The Authorised National Body shall nominate the Board of Examiners in accordance with the requirements of the doc. EWF 416.

4. Admission to the examination

Admission to the examination leading to the award of the diploma will be restricted to those who have participated in a course, approved by the Authorised National Body, according to this guideline.

Admission to the examination shall be denied for those who failed to attend 90 % of the training program. In case of special circumstances the Board of examiners may use its discretion.

5. Examination procedures

The examination procedures described below are designed to simulate the practical situations of macro- and microscopic evaluation of joints in industry. The examination comprises written and practical parts. The examination covers all subjects of this guideline.

5.1 Written examination

At the discretion of the Board of Examiners the examination shall consist of:
a series of essay questions covering the whole field of the subject, or
a series of multiple choice questions covering the whole field of the subject, or
a combination of a) and b) with equal marks allocated to each type.

The time devoted to the written examination is included in Section I, item 3, table.

5.2. Oral examination

The oral examination will be optional at the discretion of the board of examiners except in borderline cases where it will be mandatory.

5.3. Evaluation of performance

In order to pass the examination candidates must achieve at least 60% of the maximum possible mark.

5.4. Practical examination

5.4.1. COMPREHENSIVE LEVEL: Advanced techniques in metallographic examination of joints prepared/produced by welding and allied techniques

Practical examination consists of three stages:

Stage 1:

Every course participant draws a sheet containing information about a specimen subject to procedure. Introductory information received by the examinee is as follows:

- a) type (grade) of specimen material
- b) size of specimen (shape and dimensions)
- c) type of testing i.e. whether macro- or microscopic
- d) test objective e.g. revealing austenite structure in non-weathering (anticorrosive) steel
- e) laboratory equipment and device types e.g. cut-off machine, press for mounting the specimen, grinding and polishing machine, device for electrolytic etching, metallographic microscope etc.
- f) range of consumables e.g. types of resins for mounting the specimen, range of gradation for abrasive papers, polishing cloths and diamond suspensions or pastes etc.

The examinee develops a procedure and prepares the procedure of related specimen preparation.

The examinee is provided with a standard containing information and sets of etching agents for macro- and microscopic metallographic tests as well as catalogues of manufacturers.

Stage 2:

Every course participant draws a set of three scanning photographs presenting various types of fractures in steel specimens. The examination objective consists in independent and individual identification of a given type of fracture presented in the scanning photograph. In order to pass, the examinee should properly identify two out of three types of fractures.

Stage 3:

Each of the examinees draws lots of a set of three photographs revealing different microstructures characteristic for particular areas of welded or allied joints in metals or their alloys. The purpose of this stage of the examination is unaided identification of the microstructure type by the examinee on the drawn photographs. For passing the examination, it is required to identify correctly two microstructures from among three ones.

5.4.2. STANDARD LEVEL: Macro- and microscopic examination of joints prepared/produced by welding and allied techniques

Practical examination consists of two stages:

Stage 1:

Each of the examinees carries out by himself the quality assessments of a selected at random fragment of a joint with the surface prepared previously as a specimen for macroscopic examination. The examinee performs the assessment according to the defined criteria and makes the report of the macroscopic examination. During the examination each examinee has at his disposal all necessary accessories, such as a magnifying glass, weld gauge, slide caliper and a scale.

Stage 2:

Each of the examinees draws lots of a set of three photographs revealing different microstructures characteristic for particular areas of welded or allied joints in metals or their alloys. The purpose of this stage of the examination is unaided identification of the microstructure type by the examinee on the drawn photographs. For passing the examination, it is required to identify correctly two microstructures from among three ones.

5.4.3. BASIC LEVEL: Specimens preparation for macro- and microscopic examination

Each of the examinees prepares by himself the specimen for macroscopic or microscopic examination according to that which type of specimens he will perform in the future under his professional activity.

Specimen preparation for macroscopic examination comprises the following stages:

- a) precise grinding of the specimen surface with the use of a grinding machine and abrasive papers, different in grain gradation;
- b) revealing of the specimen macrostructure by chemical etching of the specimen surface by means of a suitable reagent (for instance Adler's reagent).

Specimen preparation for microscopic examination includes the following stages:

- a) precise grinding of the specimen surface with the use of a grinding machine and abrasive papers, different in grain gradation;
- b) polishing of the specimen surface on polishing cloths with the use of polishing materials (diamond based suspension or Al_2O_3 suspension) and a polishing machine;
- c) revealing of the specimen microstructure by chemical etching of the specimen surface by means of a suitable reagent (for instance Nital or FeCl_3).

The final appearance of the specimen surface for macroscopic or microscopic examination and the know-how of proceeding at each stage of specimen preparation is the subject of the examinee's skill assessment.

6. Re-examination and appeals procedure

Failure in any individual module of the examination shall require re-examination only in the module failed. Examinations shall be retaken within 2 weeks to 15 months of the initial examination and, in the case of a second failure, one further attempt is permitted within 1 to 15 months from the date of the second examination. If a candidate fails three times, he/she has to retake the classes of the course and the exams.

Candidates who feel they have been unfairly treated during the examination procedure have the right to appeal to the Authorised National Body.

The remaining procedures are covered in the doc. EWF416.

7. Transition Arrangements

An ANB can offer Transitional Arrangements for a period of up to three years from the implementation of the guideline by the ANB.

Practicing personnel in a member state will be eligible for the award of the European Diploma if they can demonstrate to the Authorised National Body that their combination of education, training and experience has provided a level of knowledge and practical skills equivalent to the current EWF requirements. If, in the judgement of the Authorised National Body, the candidate has not received an adequate level of formal training in macroscopic and microscopic examination, shall be required to attend a professional interview or examination conducted by an assessment Committee of the Authorised National Body.

Three additional general rules must be observed when applying transition arrangements.

1. Applicants must possess the basic technical access qualification as outlined for the country concerned in this guideline.
2. Only the country from which the applicant received his qualification or in which he is currently practicing can award the diploma under the transitional arrangements.
3. Qualifications (diplomas) from countries outside the EWF member states cannot be used to justify the award of a diploma under the transition arrangements.

For each country specific transition arrangements will be approved by the EWF Technical Committee, as necessary and may be obtained from the Authorised National Body.

8. Diploma

After successful examination the Authorised National Body awards the candidates the diploma of the EUROPEAN PERSONNEL WITH RESPONSIBILITY FOR MACROSCOPIC AND MICROSCOPIC METALLOGRAPHIC EXAMINATION – Comprehensive Level or Standard Level or Basic Level (Appendix B).

9. Records

The ANB maintains records of successful and unsuccessful candidates.

Appendix A

Specific Requirements for Training Centres

A.1 General

The training of the Personnel with the responsibility for MACROSCOPIC AND MICROSCOPIC METALLOGRAPHIC EXAMINATION OF STRUCTURAL MATERIALS AND THEIR JOINTS MADE BY WELDING AND ALLIED TECHNIQUES is a professional upgrading course strongly orientated to practical application. The theoretical basis and know-how in the training course is specialized in a practical as well as in a theoretical part for the qualification of a MACROSCOPIC AND MICROSCOPIC METALLOGRAPHIC EXAMINATION OF STRUCTURAL MATERIALS AND THEIR JOINTS MADE BY WELDING AND ALLIED TECHNIQUES . Therefore special requirements are necessary to be fulfilled by the Training Centers in respect to equipment, facility and specially qualified instructing personnel.

A.2 Facilities and technical equipment

Facilities and technical equipment should be of a national / international recognized standard, and follow the grinding and polishing machine, device used for electrolytic etching, fume cupboard, metallographic microscope, and measuring instruments.

A.2.1 Other equipment

Mechanical testing, metallurgical examination and NDT equipment must be available for both demonstration and laboratory work purposes.

A.2.2 Specimens

A reference collection of well documented weld specimens, polished and etched, should reflect the processes covered by the Guideline and, as a minimum, one specimen per process is required. Preferably the specimens should cover a number of materials and thicknesses, national/international safety rules and regulations. Specimens materials: low alloy steels, alloy steels, cast irons and aluminium, copper, titan, nickel and their alloys and plastics.

A.3 Qualification of instructing personnel

The Training Centers have to provide the following specially-qualified instructing personnel to guarantee a substantial training and education for the trainees:

A.3.1 Experienced Welding Supervisor (e.g. Welding Engineer, Technologist) with excellent theoretical and practical experience and knowledge in macroscopic and microscopic metallographic examination – technical university; specialization welding or material engineering, at least 3-year professional practice corresponding to the course subject-matter.

A.3.2 Experienced instructor trained and certified as a welding specialist with excellent knowledge and skill, and long term practical experience in preparing and examination of macroscopic and microscopic metallographic specimens – at least secondary technical education, in mechanical engineering and at least 3-year professional practice corresponding to the course subject-matter.

Appendix B

Layout of European Welding Personnel Diploma

**EUROPEAN FEDERATION
FOR
WELDING, JOINING AND CUTTING**

Having met the education and training requirements of EWF Guideline

'.....'

and by examination having satisfied the
requirements of the Examination Board of the
EWF Authorised National Body*[Name (forenames, given name)]***[Date of birth, (day, month, year)]**

is hereby awarded the diploma of

**EUROPEAN PERSONNEL WITH RESPONSIBILITY FOR MACROSCOPIC
AND MICROSCOPIC METALLOGRAPHIC EXAMINATION****Basic Level (Standard Level or Comprehensive Level)***[Date: day, month, year]***[Diploma No.: ISO country code/
category/ unique serial code]***[Signature]***[Signature]***[Name]***[Chairman of Examination Board]***[Name]***[Head of Training School]***[IIW Authorised National Body: Name of ANB and Country]**[logo or stamp of ANB]*(optional)**** - TO BE PRINTED BY THE ANB**